Bulletin 252 June, 1932

The Fertilization of Apple Orchards. III: A Comparison of Nitrate of Soda and Sulphate of Ammonia

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The Fertilization of Apple Orchards. III: A Comparison of Nitrate of Soda and Sulphate of Ammonia *

by H. E. KNOWLTON and M. B. HOFFMAN†

WITH the widely prevalent practice of applying quickly available nitrogenous fertilizers to apple trees have come questions as to the comparative value of the several forms on the market. In making a choice several factors must be considered besides that of actual effects on growth and yield of fruit. Among the most important are comparative costs per unit of nitrogen, mechanical conditions as affecting ease of application, and effects upon the soil reaction.

A number of rather quickly available nitrogenous fertilizers are now on the market. Some are being widely used. Others have not been on sale long enough to demonstrate their value and consequently have not come into general use.

At the time the experiments reported herein were started, only two quickly available nitrogen fertilizers, nitrate of soda and sulphate of ammonia, had attained sufficient importance to warrant testing their comparative value. Nitrate of soda, the older commercial form of nitrogen, contains 15.6% nitrogen, and is probably the most widely used of nitrogen fertilizers in the orchard. It is an imported product, being mined in Chile as guano, purified, and sold to the trade as Chilean nitrate of soda. Most of the nitrate of soda on the market comes from this source, although some is now being produced synthetically. Sulphate of ammonia contains from 20.5 to 20.8% nitrogen and comes from two sources: (1) a by-product obtained from the coking of coal and the production of gas, and (2) a synthetic product involving the fixation of atmospheric nitrogen. Production by the latter method is increasing rapidly and almost equals in tonnage that from by-product sources.

Both forms of nitrogen have good mechanical properties — at least in comparison with other less widely-known products such as cyanamid and calcium nitrate. Both nitrate and sulphate tend to take up moisture when exposed to the atmosphere and as a result form hard lumps. Nitrate of soda is worse in this respect, although in the last year or two changes have been made in the product tending to obviate this defect.

A comparison of the relative costs of these fertilizers is of interest from the practical standpoint. In 1931 for the first time sulphate of ammonia cost less per ton than nitrate of soda, although the former contains one-third more nitrogen. In 1932 cost differences are still more striking, as seen in Table 1.

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*This is the third in a series of bulletins issued by this Station on fertilization of apple orchards. Those previously published are W. Va. Agr. Exp. Sta. Bulletins 174 and 203.

†Mr. Hoffman resigned September, 1931.

TABLE 1—*Comparative wholesale* prices of several nitrogenous fertilizers per ton and per unit (20 pounds) of nitrogen. February, 1932*

Nitrogen carrier	Wholesale price per ton	Percent nitrogen content	Price per unit of nitrogen
Nitrate of soda	$40.00	15.6	2.56
Sulphate of ammonia	30.00	20.6	1.45
Cyanamid	32.00	22.0	1.45

*Prices obtained from Baugh and Sons, Baltimore, Md.

THE WEST VIRGINIA EXPERIMENTS

Four experiments are reported in this bulletin. Two are located in the orchard of Mr. L. E. Reynolds near St. Marys, Pleasants County, on the hills above the Ohio River Valley. These will be designated as Experiments I and II. A third experiment (Experiment III) is located in the orchards of Mr. E. F. McDonald near Darkesville, Berkeley County, in the Eastern Panhandle. A fourth experiment (Experiment IV) is in an orchard on a farm known as the Burns place, owned by Frank B. Robinson, near Charles Town, Jefferson County, also in the Eastern Panhandle. Two markedly different soil types are represented, one belonging to the Dekalb and the other to the Hagerstown series.

The St. Marys Experiment

Experiment I was begun in the spring of 1922 on 32-year-old Rome trees. While each tree had received 5 pounds of nitrate of soda in 1921, average terminal growth was only 2 to 3 inches that year. Fertilization in previous years had been inadequate and intermittent. The experiment included four rows or plots of 10 to 12 trees each, located adjacent to the St. Marys fertilizer experiment reported in Bulletins 174 and 203 of this Station. Kinds of fertilizer, time of application, and amounts used per tree were as follows:

Plot 11, 5.2 pounds of nitrate of soda 10 to 15 days before bloom
Plot 12, 5.2 pounds of nitrate of soda at bloom
Plot 13, 3.9 pounds of sulphate of ammonia 10 to 15 days before bloom
Plot 14, 3.9 pounds of sulphate of ammonia at bloom

The report on this experiment covers the period from 1922 to 1927, inclusive.

Experiment II was begun in the same orchard in the spring of 1926. Twenty-four trees were carefully selected according to size and paired to facilitate treatment of data by Student's method. Twelve trees received 5.2 pounds of Chilean nitrate of soda and twelve trees, 3.9 pounds of Arcadian sulphate of ammonia 10 to 15 days before bloom. Only three years' data (1926-1828) were taken, as the experiment had to be discontinued because of changes in the management of the orchard.

Soil in the above-described experiments is a Dekalb silt loam, low in fertility, with a lime requirement of 2 to 3 tons per acre. The sod mulch system of soil management has been used but the soil is

so poor that only a sparse growth of grass and weeds could be supported.

Eastern Panhandle Experiments

Experiment III* was begun in the spring of 1925 on nine-year-old Jonathan trees in the McDonald orchard at Darkesville, Berkeley County. Thirty trees were carefully selected to facilitate pairing by Student's method. Ten trees received 5 pounds of Chilean nitrate of soda, ten trees 3.8 pounds of Arcadian sulphate of ammonia, and ten trees were left unfertilized. Fertilizer applications were made at bloom time instead of 2 to 3 weeks before, as is the common practice. The trees stood in a rather heavy sod, in poor vigor, and were small for their age at the time the studies were begun.

The soil is a Hagerstown clay loam, with occasional lime outcrops, and of average fertility. Lime requirement varies from zero to about a ton per acre.

Experiment IV was started in the spring of 1926 on 25-year-old Arkansas (Black Twig) apple trees in the Robinson (Burns place) orchard in Jefferson County. The Black Twig trees are set 35 x 40 feet with Grimes interplanted one way, making the planting distance 20 x 35 feet. Twenty-four pairs of trees selected for uniformity in size are included in the experiment. One half of the trees have received 4 pounds of Chilean nitrate of soda and the other half, 3 pounds of Arcadian sulphate of ammonia 2 to 3 weeks before bloom. Most of the interplanted Grimes were alive at the beginning of the studies, but they have rapidly been dying with collar blight in the subsequent five years. Because of this, certain pairs adjacent to dead Grimes trees have been discarded during the course of the work.

The soil is a Hagerstown clay loam of good fertility with outcrops of limestone scattered here and there through the orchard. At the beginning of the studies the orchard was in alfalfa. Since then the alfalfa has gradually been choked out by grass and weeds with the result that in 1931 the owner had to break up the sod and reseed it to alfalfa. Lime requirement averaged about a ton per acre at the beginning of the experiment.

COMPARATIVE EFFECTS OF NITRATE OF SODA AND SULPHATE OF AMMONIA ON GROWTH

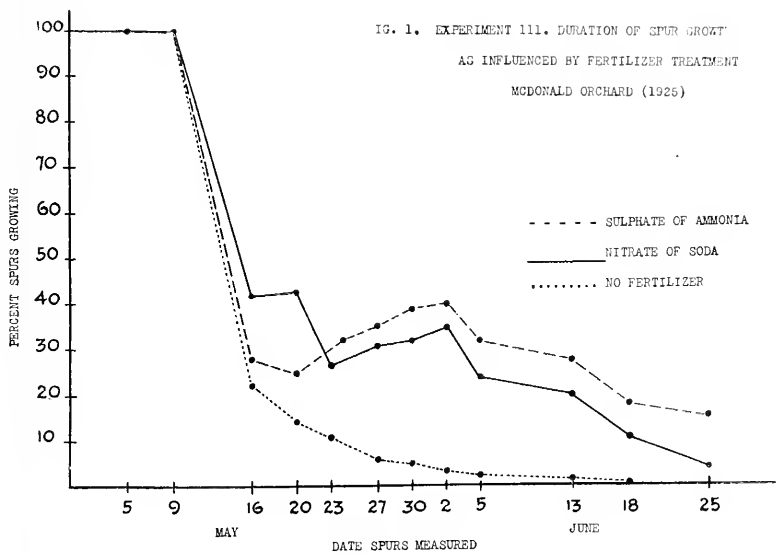
The growth response in these experiments was determined each season by measuring terminal elongation on each tree. While increase in trunk circumference is generally a reliable index of growth, it was believed that in these studies it would be less dependable than terminal growth, for in many of the pairs selected, bearing surfaces were approximately the same on trees with unequal trunk circumferences. In such pairs variation in height of head may have been responsible for the differences.

*Mr. R. C. McDonald collected most of the data on this experiment while a graduate student in West Virginia University.

In taking the terminal twig measurements. twenty shoots were selected at random from the limbs around the sides of the tree, and the total length was taken. It was realized that this figure did not give an index of the actual amount of terminal growth being made by a tree, since growth in the tops is usually greater than around the sides, but it did offer a reliable basis for comparing the effects of the several treatments.

In Experiments I and II, in the Reynolds orchard at St. Marys, no significant differences in growth were found. Both terminal growth and trunk circumference measurements were taken.

Both spur and terminal growth measurements were obtained in the McDonald orchard (Experiment III) in 1925 and 1926. Ten terminals and ten spurs were tagged on each tree in the spring of 1925, and exact measurements of elongation were taken at regular intervals. Results are shown graphically in Figures 1 and 2. (Each point on the curves is the mean of 100 measurements.)



These curves show that nitrate of soda is a more quickly acting fertilizer than sulphate of ammonia where both were applied at bloom, but the effect of the latter extends over a longer period. However, total terminal growth at the end of each season was significantly greater where nitrate of soda was used.

In Experiment IV in the Robinson orchard only terminal growth measurements were taken. Results are shown in Table 2. No significant differences were obtained.

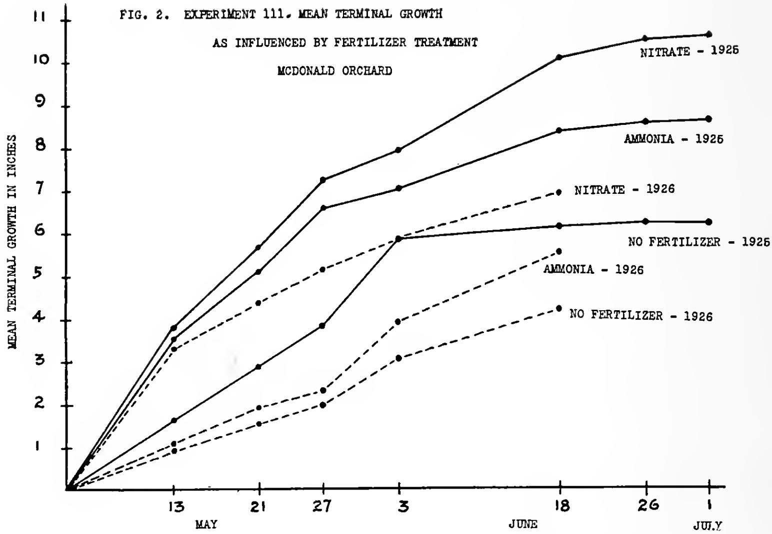


FIG. 2. EXPERIMENT 111. MEAN TERMINAL GROWTH AS INFLUENCED BY FERTILIZER TREATMENT MCDONALD ORCHARD

COMPARATIVE EFFECTS OF NITRATE OF SODA AND SULPHATE OF AMMONIA ON FRUITFULNESS

Records on fruit set were taken whenever conditions indicated that such data would yield valuable information on fertilizer effects. In taking these data several representative branches on each tree were tagged at blossoming time, and the number of flower clusters was counted. The number of fruit setting was determined later, generally before the June drop, and the percentage figured.

Total yield records (picked fruit and "drops") were taken for each tree in bushels (by volume rather than by weight measurements).

TABLE 2—*Experiment IV. Comparative effects of nitrate of soda and sulphate of ammonia on total terminal growth in feet of Black Twig in the Robinson (Burns place) orchard (1926-1930). Materials applied 2 to 3 weeks before bloom. Comparison by Student's method**

Pair	Total growth on trees receiving		d	d^2	Z= .50
	Sodium nitrate	Ammonium sulphate			
1	57	65	— 8	64	
2	53	37	+16	256	
3	61	72	—11	121	
4	72.5	80	— 7.5	56.25	Odds of
5	74.5	81	— 6.5	42.25	17.3:1 in
6	68	77	— 9	81	favor of
7	61	77	—16	256	ammonium
8	77	78	— 1	1	sulphate
9	76	83	— 7	49	
10	81	80	+ 1	1	
11	57	60	— 3	9	
12	71.5	63.5	+ 8	64	
13	58	57	+ 1	1	
14	35.5	68.5	—33	1089	

*In calculating odds, N equals degrees of freedom, or one less than the number of frequency classes. Odds must be at least 30:1 to be significant.

Set of Fruit

In Experiment I in the Reynolds orchard, records on set of fruit showed no consistent differences between sodium nitrate and ammonium sulphate when these were applied early. When applied at bloom, nitrate gave increases over sulphate of ammonia in all four years in which records were taken. Early applications of both fertilizers gave marked increases over the same fertilizers applied at bloom. This is shown in Table 3.

In Experiment II in the Reynolds orchard, fruit-set records were taken in 1926 and 1928. In 1926 odds were 3:1 and in 1928, 10:1 in favor of sulphate of ammonia — insignificant odds in all cases.

TABLE 3—*Experiment I. Comparative effects of nitrate of soda and sulphate of ammonia on set of fruit of Rome in the Reynolds orchard*

Treatment	Percent set			
	1923°	1924*	1925°	1926°
†Early sodium nitrate	16.4	38.8	8.3	7.3
Sodium nitrate at bloom	13.7	26.4	7.0	2.7
†Early ammonium sulphate	10.7	41.5	9.3	5.0
Ammonium sulphate at bloom	9.5	17.2	5.8	1.7

†2 to 3 weeks before bloom.
°After June drop.
*Before June drop.

TABLE 4—*Experiment III. Comparative effects of nitrate of soda and sulphate of ammonia on percent set of fruit in the McDonald orchard. Materials applied at bloom. Comparison by Student's method*

Pair	Set of fruit from trees receiving in 1925:		Set of fruit from trees receiving in 1926:	
	Sodium nitrate	Ammonium sulphate	Sodium nitrate	Ammonium sulphate
1	52.6	16.2	58.0	38.6
2	64.5	12.4	31.3	20.9
3	68.7	19.8	28.8	10.5
4	74.1	13.0	82.5	31.3
5	53.2	20.8	80.2	33.0
6	47.5	28.8	30.1	43.2
7	61.1	17.5	48.0	16.4
8	61.5	36.9	23.0	20.9
9	61.6	20.9	47.0	41.2
10	42.8	22.7	70.4	23.4
	Z = 2.83 Odds > than 9999:1 in favor of sodium nitrate		Z = 1.07 Odds 120:1 in favor of sodium nitrate	

In Experiment III at the McDonald orchard, set records were taken five weeks after bloom in 1925 and 1926. Odds in both years were significantly in favor of nitrate of soda. These results are shown in Table 4.

Records of set of fruit in the Robinson orchard (Experiment IV) were taken in 1926, 1928, and 1929. Frosts at bloom in 1927 and 1930 damaged the buds to such an extent that reliable records on set could not be taken. In 1926 these data showed odds of 6:1 in favor of nitrate of soda. In 1928 odds were 3:1 and in 1929, 7:1, both in favor of sulphate of ammonia — insignificant odds in all three years.

Yield of Fruit

In Experiments I and II in the Reynolds orchard yield records showed no significant differences where nitrate of soda and sulphate of ammonia were used.

In Experiment III in the McDonald orchard yield records show significant differences in favor of nitrate of soda (Table 5). The average annual tree yield of the check trees in this test was slightly more than one quarter bushel, showing that nitrogen was particularly needed in this soil.

TABLE 5—*Experiment III. Comparative effects of nitrate of soda and sulphate of ammonia on total yield in bushels of Jonathan in the McDonald orchard (1925-1927). Materials applied at bloom. Comparison by Student's method*

Pair	Total yield from trees receiving: Sodium nitrate	Ammonium sulphate	d	d^2	Z=1.0
1	6.9	5.3	+1.6	2.56	
2	6.0	4.4	+1.6	2.56	
3	2.3	1.3	+1.0	1	Odds of 89:1:1 in favor of nitrate of soda
4	7.5	4.5	+3.0	9	
5	4.5	1.0	+3.5	12.25	
6	5.4	5.8	— .4	.16	
7	8.6	1.0	+7.6	57.76	
8	6.8	5.3	+1.5	2.25	
9	2.6	3.3	— .7	.49	
10	7.4	4.5	+2.9	8.41	
Average annual tree yield	1.93	1.21	Average annual increase of nitrate of soda over sulphate of ammonia, 0.72 bushels		

Yields for the six-year period (1926-1931) in the Robinson orchard (Experiment IV) are shown in Table 6. Here there are significant differences in favor of sulphate of ammonia.

NITROGENOUS FERTILIZERS AND SOIL ACIDITY

Considerable attention in these experiments was given to the relative effects of nitrate of soda and of sulphate of ammonia on soil reaction. It has been known for a long time that sulphate of ammonia tends to make the soil acid, while nitrate of soda makes it alkaline. There are various theories to explain why sulphate of ammonia brings about an acid soil reaction. These theories are discussed by Pierre *(2)*. The generally accepted theory regarding nitrate of soda is that when it is added to the soil there is a greater absorption by the plant of the nitrate ion, leaving the basic sodium in the soil.

In Experiment I in the Reynolds orchard at St. Marys, soil acidity determinations were made in March, 1931, four years after the experiment had been discontinued. One boring was made 4 feet from each tree to a depth of 12 inches. Hydrogen-ion determinations of soil were paired and their significance was determined by Student's method. Results as seen in Table 7 show significantly greater acidity at 0 to 4 and 4 to 8 inches depth where sulphate of ammonia was used. Odds at 8 to 12 inches were least (25.5:1), indicating that

most of the acid effect of the sulphate of ammonia was near the surface.

TABLE 6—*Experiment IV. Comparative effects of nitrate of soda and sulphate of ammonia on total yield in bushels of Black Twig in the Robinson orchard (1926-1931). Materials applied 2 to 3 weeks before bloom. Comparison by Student's method*

Pair	Total yield from trees receiving:		d	d^2	Z = .6
	Sodium nitrate	Ammonium sulphate			
1	40.45	32.7	+ 7.75	60.0625	
2	38.1	29.9	+ 8.2	67.24	
3	47.5	62.1	—14.6	213.16	
4	73.4	74.9	— 1.5	2.25	Odds 32.4:1 in favor of ammonium sulphate
5	46.8	72.7	—25.9	670.81	
6	42.2	49.9	— 7.7	59.29	
7	62	77	—15	225	
8	76.65	73.9	+ 2.75	7.5625	
9	48.30	51.8	— 3.5	12.25	
10	49.3	53.5	— 4.2	17.64	
11	75.6	94.3	—18.7	349.69	
12	82.2	69.9	+12.3	151.29	
13	41.3	84.15	—42.85	1836.12	
14	40.4	59.7	—19.3	372.49	
Average annual tree yield	9.1	10.5	Average annual increase of sulphate of ammonia over nitrate of soda, 1.4 bushels		

Soil acidity determinations were made also in the Robinson orchard, with similar results. Computed in terms of lime requirement the average difference between the nitrate of soda and the sulphate of ammonia plots in this experiment is 1800 pounds of ground limestone per acre. These determinations were made in 1931 after five years of fertilization. It should be mentioned that these differences do not actually represent the acidifying action of the sulphate of ammonia. Nitrate of soda tends to make soils alkaline. Both reactions, opposite in effect, have therefore been going on during the course of the studies. Roughly speaking, the "souring" power of sulphate of ammonia is about twice the "sweetening" power of nitrate of soda.

DISCUSSION

In the studies reported in this bulletin sulphate of ammonia gave as good results as nitrate of soda in the two experiments in the Reynolds orchard when the applications were made early. Soil in this orchard is low in fertility and markedly acid in reaction. It is under such acid conditions that ammonia cannot be directly assimilated, according to Tiedjens and Robbins *(5)*, who grew one-year-old apple trees in sand at pH 5.4. Leaves were yellow in color. On the other hand, they found that trees supplied with calcium nitrate grew very well at this hydrogen-ion concentration. When the pH of the soil supplied with ammonium sulphate was increased to 8, the leaves turned green and growth was resumed. If ammonia is not assimilated directly by trees in an acid soil it must first be nitrified before being used. In an acid soil this goes on slowly. According to Waksman *(6)*, nitrification is stopped at a hydrogen-ion concentra-

tion of 4.4 to 4.8 pH. As shown in Table 7, some of the determinations of hydrogen-ion concentrations for this soil were as low as Waksman *(6)*, nitrification is stopped at a hydrogen-ion concentraman and Pierre, of this Station, it was found that considerable nitrification occurs in some soils at hydrogen-ion concentrations below even 4.0. Nitrification of the ammonia must have gone on in the Reynolds orchard, for fertilizer was put on the surface and little of the nitrogen could leach downward in the ammonia form and come in contact with the tree roots.

TABLE 7—*Experiment I. Comparative soil acidity effects produced by nitrate of soda and sulphate of ammonia in the Reynolds orchard*

Pair	Hydrogen-ion concentrations of soil under trees receiving:					
	Sodium nitrate	Ammonium sulphate	Sodium nitrate	Ammonium sulphate	Sodium nitrate	Ammonium sulphate
	Soil depth 0 to 4 inches		Soil depth 4 to 8 inches		Soil depth 8 to 12 inches	
1	5.0 pH*	4.5 pH	4.9 pH	4.6 pH	4.7 pH	4.9 pH
2	5.4	4.7	5.4	4.9	5.6	4.8
3	5.2	4.6	5.2	4.6	5.2	4.9
4	5.0	4.7	5.1	4.8	5.1	4.9
5	4.6	4.7	4.5	4.7	4.7	4.7
6	4.7	4.0	4.7	4.4	4.7	4.7
7	4.8	4.8	4.8	4.7	4.7	5.0
8	5.5	4.6	5.4	4.6	5.1	4.7
9	5.4	4.9	5.4	5.1	5.4	5.1
10	4.7	4.7	4.9	5.1	5.0	5.1
11	5.1	4.3	5.7	4.6	5.7	4.8
12	5.5	4.9	5.6	5.1	5.5	5.1
	Z = 1.45 Odds 1999:1 in favor of ammonium sulphate		Z = .98 Odds 174.6:1 in favor of ammonium sulphate		Z = .63 Odds 25.5:1 in favor of ammonium sulphate	

*A pH value of 7 indicates neutrality; lower values indicate acidity, and higher values indicate alkalinity.

When applications of fertilizers were made at bloom time, nitrate of soda was distinctly better than sulphate of ammonia in both the Reynolds orchard (Experiment I) and the McDonald orchard (Experiment III). Both soils were acid and under these conditions ammonia probably was not directly assimilated *(5)*. Nitrification changed the ammonia to nitrate — a form that could be used by the apple trees. Under spring conditions in an acid soil this change goes on slowly and trees do not get enough nitrogen in time to affect set, spur, and terminal growth as greatly as when nitrate of soda is applied. The slow release of this form of nitrogen is indicated by the data on duration of spur growth shown graphically in Figure 1. When both forms of nitrogen are applied early (10 to 15 days before bloom), nitrification seemingly goes on rapidly enough so that sufficient nitrates are absorbed by the trees and translocated to the fruiting parts in time materially to aid fruit set and wood growth.

In the Robinson orchard, where nitrate of soda and sulphate of ammonia have been applied 2 to 3 weeks before bloom, yield has been significantly greater where the latter has been used. The significance is not particularly marked, however, and it is questionable whether it indicates any distinct superiority.

Anthony *(1)* has found that trees in heavy bluegrass sods are

able to get little of the nitrogen when applied early as nitrate of soda or sulphate of ammonia because the grass gets most of it first. Sulphate of ammonia is much more likely to be absorbed by grass sods than nitrate of soda, because nitrogen in the form of ammonia will not be leached downward within the tree root zone until after nitrification has occurred. Under the generally adverse conditions of early spring this goes on slowly and in the meantime the ammonia is being utilized by the sod, since ammonia as well as nitrate can probably be assimilated directly by grasses. It is possible that this explains why Anthony got better results from nitrate of soda than from sulphate of ammonia in his early applications. This explanation is also suggested by Anthony. It may also explain Auchter and Schrader's *(4)* findings in Maryland, where they got better results the first few years from the use of nitrate of soda in a sod orchard. They give no data on soil reaction, but from the general description of the soil one would conclude that it was quite acid. It should be mentioned that the sod in the Reynolds orchard was very thin; it is therefore doubtful that it got most of the nitrogen. On the other hand, the sod in the McDonald orchard was a heavy bluegrass. This may be a factor in the poor showing of sulphate of ammonia in this experiment, although it is probable that sulphate of ammonia would have shown up better if the fertilizers had been applied early.

If cover crops, particularly leguminous ones, are to be grown, continued use of sulphate of ammonia will make it difficult to do so unless the soil is limed. According to Pierre *(3)*, for every ton of ammonium sulphate a little over a ton of ground limestone should be used to counteract acidity. Since the cost of a unit of nitrogen in sulphate of ammonia is little more than one half the cost in nitrate of soda, the apple orchardist can well afford to add lime.

SUMMARY

Four fertilizer experiments comparing nitrate of soda and sulphate of ammonia with apple trees are reported in this bulletin. A brief review of each experiment with the results obtained follows:

Experiment I was started in 1922 with 32-year-old Rome trees in the Reynolds orchard at St. Marys, Pleasants County. This report covers the period from 1922 to 1927. Early applications of both fertilizers were superior to those made at bloom. Nitrate of soda was superior to sulphate of ammonia when both were applied at bloom. When applied 10 to 15 days before, there were no significant differences in results obtained from the two fertilizers.

Experiment II was begun in 1926 with 36-year-old Rome trees in the same orchard. Fertilizers were also applied 10 to 15 days before bloom. No differences in growth or yield were obtained.

Experiment III was begun in 1925 on 9-year-old Jonathan trees in the McDonald orchard at Darkesville in Berkeley County. Fertilizers were applied at bloom time. Nitrate of soda was significantly superior to sulphate of ammonia in both growth and fruitfulness.

Experiment IV was begun in 1927 on 25-year-old Black Twig trees in the Robinson orchard, Jefferson County. Fertilizers were applied 2 to 3 weeks before bloom. No differences in growth were observed between trees fertilized with nitrate of soda and those fertilized with sulphate of ammonia. Significant differences in yield were obtained, the trees fertilized with sulphate of ammonia yielding more. The significance, however, was not particularly marked.

Soil acidity determinations were made in Experiments I and IV. Sulphate of ammonia tended to make the soil acid. In Experiment IV, after fertilizer applications had been made for five years, the difference in lime requirement between nitrate and ammonia plots averaged 1800 pounds per acre.

NITROGEN FERTILIZER RECOMMENDATIONS

The choice between the use of nitrate of soda and sulphate of ammonia in the apple orchard should be determined by their relative cost in terms of nitrogen units. At this time a unit of nitrogen in sulphate of ammonia costs little more than one half what it costs in nitrate of soda, and is equally valuable as a fertilizer if applied two to three weeks before bloom. To insure full value from sulphate of ammonia it should be applied at least two weeks before bloom, and should be worked into the soil where early cultivation is being practiced. In figuring comparative costs of the two nitrogen carriers it should be borne in mind that eventually lime must be applied to correct the acidity of the sulphate of ammonia particularly if legume cover crops are grown. In such cases the lime requirement should be determined and the amount needed to correct acidity should be applied.* Addition of lime will not only help the cover crop but also tend to make the ammonia more quickly available.

*The Agricultural Experiment Station will determine lime requirements for West Virginia orchards free of charge. In taking soil samples in an orchard where sulphate of ammonia has been applied to the soil under the trees, proceed as follows: On each soil type or area given the same treatment in the past, take a boring of soil to a depth of 6 inches under 10 to 12 different trees. Thoroughly mix the soil from these borings. Take a pint sample of this. Prepare a second sample by making the same number of borings in the area beyond the spread of tree branches where the sulphate of ammonia has not been put on. Mail samples in tight containers to the Department of Agronomy at Morgantown. If an auger is not available for making the borings, a perpendicular 6-inch slice of soil can be removed with a trowel or spade.

LITERATURE CITED

1. Anthony, R. D. sulphate of ammonia and nitrate of soda in a sod orchard. Penn. Agr. Exp. Sta. Bul. 249. 1930.
2. Pierre, W. H. nitrogenous fertilizers and soil acidity: i. effect of various nitrogenous fertilizers on soil reaction. Jour. Am. Soc. Agron. 20:3:254-269. 1928.
3. ————. nitrogen fertilizers and soil acidity. Mountaineer Grower: 3:24:64-68. 1932.
4. Schrader, A. L. and E. C. Auchter. the comparative effects of different nitrogen fertilizers on bearing apple trees low in vigor. Proc. Am. Soc. Hort. Sci. 24:229-233. 1927.
5. Tiedjens, V. A. and W. R. Robbins. the use of ammonia and nitrate nitrogen by certain crop plants. N. J. Agr. Exp. Sta. Bul. 526. 1931.
6. Waksman, S. A. microbiological analysis of soils as an index of soil fertility: v. methods for the study of nitrification. Soil Sci. 15:241-260. 1923.